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Deep-sea sharks as by-catch of an experimental fishing survey for black scabbardfishes (*Aphanopus* spp.) off the Canary Islands (NE Atlantic)

Mafalda Freitas^{1,2}, Luísa Costa¹, João Delgado³, Sebastián Jiménez⁴, Viriato Timóteo³,
Joana Vasconcelos³, José A. González⁵

¹ OOM - Funchal Marine Biology Station and Marine and Environmental Sciences Centre (MARE), Funchal, Madeira, Portugal.

(MF) (corresponding author) E-mail: mafalda.freitas@cm-funchal.pt. ORCID-iD: <https://orcid.org/0000-0002-2758-7177>

(LC) E-mail: luisa.costa@cm-funchal.pt. ORCID-iD: <https://orcid.org/0000-0001-9107-6200>

² OOM - Funchal Natural History Museum, Rua da Mouraria 31, Funchal, Madeira, Portugal.

³ OOM - Research Service, Regional Directorate of Fisheries, Funchal, Madeira, Portugal.

(JD) E-mail: joao.delgado@madeira.gov.pt. ORCID-iD: <https://orcid.org/0000-0003-4268-7202>

(VT) E-mail: viriatotimoteo@gmail.com

(JV) E-mail: joana.pr.vasconcelos@madeira.gov.pt. ORCID-iD: <https://orcid.org/0000-0003-3880-2554>

⁴ Instituto Español de Oceanografía, Centro Oceanográfico de Canarias, Vía Espaldón PCL8, Dársena Pesquera, 38180 Santa Cruz de Tenerife, Spain.

(SJ) E-mail: sebastian.jimenez@ieo.es. ORCID-iD: <https://orcid.org/0000-0002-6534-4096>

⁵ Applied Marine Ecology and Fisheries, i-UNAT, Universidad de Las Palmas de Gran Canaria, Campus Universitario de Tafiara, 35017 Las Palmas de Gran Canaria, Spain.

(JAG) E-mail: pepe.solea@ulpgc.es. ORCID-iD: <https://orcid.org/0000-0001-8584-6731>

Summary: The deep-sea sharks associated as by-catch of the Madeiran midwater drifting longline fishery for scabbardfishes (*Aphanopus* spp.) were investigated by means of an experimental survey at 800-1200 m depth within the Canary Islands Exclusive Economic Zone, whose fishing grounds have been exploited during the past 15 years. Nine species of chondrichthyans were identified, belonging to five families: Pseudotriakidae, Centrophoridae, Etmopteridae, Somniosidae and Chimaeridae. Data on length, weight and sex ratio for the 436 chondrichthyan individuals caught in the March 2009 survey are given. Several voucher specimens of each species caught were deposited in the collections of the Natural History Museum of Funchal.

Keywords: by-catch; deep-sea Chondrichthyes; midwater drifting longline; NE Atlantic.

Tiburones de profundidad en las capturas accesorias de una campaña de pesca experimental de pez sable negro (*Aphanopus* spp.) en las islas Canarias (Atlántico nororiental)

Resumen: Se investigaron los tiburones de profundidad en las capturas accesorias de la pesquería de palangre de deriva de media agua que tiene por objetivo el sable negro (*Aphanopus* spp.) mediante una campaña experimental en la Zona Económica Exclusiva de Canarias a profundidades de 800 a 1200 m, en caladeros que han venido siendo explotados en los últimos 15 años. Se identificaron nueve especies de condricios pertenecientes a cinco familias: Pseudotriakidae, Centrophoridae, Etmopteridae, Somniosidae y Chimaeridae. Se aportan datos de talla, peso y proporción de sexos para los 436 ejemplares de condricios capturados en la campaña de marzo de 2009. Los especímenes de referencia capturados fueron depositados en las colecciones del Museo de Historia Natural de Funchal.

Palabras clave: capturas accesorias, condricios de profundidad, palangre de deriva de media agua, Atlántico nororiental.

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INTRODUCTION

The deep-sea fishery of the bathypelagic black scabbardfishes, *Aphanopus carbo* and *A. intermedius*, has a long tradition off the Portuguese mainland and around the Madeira archipelago, representing one of the world's longest standing exploitations of meso- and bathypelagic fishes (Delgado et al. 2013, 2018). Off Madeira this fishery is performed with midwater drifting longlines set between 800 and 1200 m depth over the continental slope and nearby seamounts. This is one of the oldest known fisheries in the world targeting a deep-water resource (Leite 1988).

A preliminary study on the by-catch and incidental catch of a potential black scabbardfish (*Aphanopus* spp.) fishery off the Canary Islands, based on a few experimental surveys on board research vessels, was published by Pajuelo et al. (2010).

Ten years ago, Portugal and Spain signed an agreement to study the impact of the black scabbardfish fishery off the Canary Islands, using commercial fishery vessels from Madeira in an experimental survey. The main objectives were i) to study deep-sea sharks as a by-catch of this Madeiran fishery off the Canary Islands, and ii) to compare this by-catch with the by-catch off Madeira and the Portuguese mainland with the same fishing system. The results of this survey are now presented on this short paper.

MATERIALS AND METHODS

In March 2009 an experimental fishing survey was carried out off the Canary Islands between 800 and 1200 m depth using black scabbardfish midwater drifting longlines of the Madeiran type. This fishing gear has 5000 hooks (type 6) (Martins and Ferreira 1995) and is usually set well above the bottom in the water column between 700 and 1300 m depth, without contacting the seafloor (Delgado et al. 2018). Fishing operations were carried out by two Madeiran profes-

sional vessels, F/V *Pico Dourado* and F/V *Pico Alto*, with scientific observers on board. In accordance with Canary Islands legislation restrictions (no more than 500 hooks per longline are permitted), both vessels used two separate longlines, one much longer than the other: a professional one with around 5000 hooks and an experimental one with around 500 hooks. The neon flying squid *Ommastrephes bartramii* was used as bait in all longlines. Twenty hauls were carried out off the islands of Tenerife, La Gomera, La Palma, Fuerteventura and El Hierro (Fig. 1). The sampled areas were not randomly selected, but based on the captains' experience from the fishery grounds, as well as on the target species' vertical distribution in the area (Pajuelo et al. 2008).

Shark individuals caught were identified following Compagno et al. (2005) and then counted and weighed by species on board. Catches of chondrichthyans and CPUE values by fishing operation (location) were calculated, as well as an average CPUE per island. CPUE values were expressed in kg (total weight) per 1000 valid hooks. For each species caught, all individuals or well-representative subsamples were selected and preserved on board and then measured (total length TL, in mm), weighed (total weight TW, in g), and sexed at the laboratory.

Several voucher specimens of each species caught were deposited in the collections of the Natural History Museum of Funchal (MMF).

RESULTS

A total of 436 individuals of 9 mesopelagic species of Chondrichthyes belonging to 5 families (Pseudotriakidae, Centrophoridae, Etmopteridae, Somniosidae and Chimaeridae) were captured. The leafscale gulper shark (*Centrophorus squamosus*) (Centrophoridae), represented by 170 individuals, was the most abundant species. The velvet dogfish (*Zameus squamulosus*) (n=129) and the roughskin dogfish (*Centroscymnus*

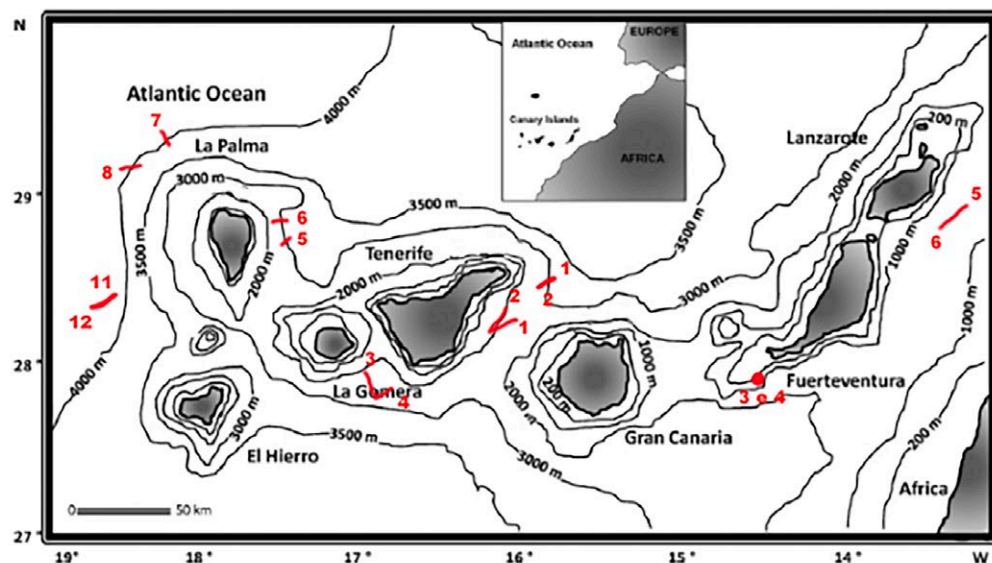


Fig. 1. – Map of the Canary Islands showing set locations off the islands of Tenerife, La Gomera, La Palma, Fuerteventura and El Hierro.

Table 1. – Chondrichthyan species caught, with number of individuals, descriptive statistics for size and weight, and sex ratio (males:females). Size as total length (TL); weight as total weight (TW).

Species	Common name	Individuals caught	Individuals studied	Mean TL±sd (mm)	TL range (mm)	Mean TW±sd (g)	TW range (g)	Sex ratio (M:F)
<i>Centrophorus granulosus</i>	Gulper shark	10	8	970±141	850-1520	5100±2687	3200-26000	1:1
<i>Centrophorus squamosus</i>	Leafscale gulper shark	170	132	1070±98	820-1370	7120±2487	3200-23000	1:0.08
<i>Etmopterus princeps</i>	Great lanternshark	3	3	448±48	400-495	333±115	200-400	1:2
<i>Etmopterus pusillus</i>	Smooth lanternshark	1	1	-	470	-	400	-
<i>Centroscyrnus owstonii</i>	Roughskin dogfish	121	118	681±85	505-835	1174±478	200-2400	1:6.4
<i>Zameus squamulosus</i>	Velvet dogfish	129	129	633±100	460-800	1132±638	400-2700	1:1.6
<i>Pseudotriakis microdon</i>	False catshark	1	1	-	2100	-	33000	-
<i>Chimaera monstrosa</i>	Rabbit fish	1	1	-	462	-	580	-

Table 2. – Catches of chondrichthyans and CPUE values per fishing operation (location), with an average CPUE per island. CPUE expressed in kg (total weight) per 1000 hooks.

Sector/island (location)	Number of hooks (valid)	Catches of chondrichthyans (kg)	CPUE (kg/1000 hooks)	Average CPUE per island
SW El Hierro	400	0.00	0.00	El Hierro: 31.46
SW El Hierro	1800	0.00	0.00	
SW El Hierro	400	0.00	0.00	
SW El Hierro	3200	0.00	0.00	
NE El Hierro	400	70.11	175.28	Fuerteventura: 182.96
NE El Hierro	5200	70.11	13.48	
SW Fuerteventura	400	85.69	214.23	
SW Fuerteventura	3800	576.46	151.70	
E La Palma	1033	23.37	22.62	La Palma: 28.35
NE La Palma	3878	31.16	8.04	
NW La Palma	5669	249.28	43.97	
NW La Palma	402	15.58	38.76	
S Lanzarote	3800	0.00	0.00	Lanzarote: 0.00
S Lanzarote	400	0.00	0.00	
NE Tenerife	415	7.79	18.77	
NE Tenerife	4939	109.06	22.08	
SE La Gomera - SW Tenerife	1027	7.79	7.59	Tenerife: 23.22
SE La Gomera - SW Tenerife	411	0.00	0.00	
S Tenerife	400	31.16	77.90	
S Tenerife	4800	62.32	12.98	

owstonii) (n=121) (both Somniosidae) were well-represented in the catches. The capture of the other five chondrichthyans could be considered as incidental (Table 1).

Apart from the list of chondrichthyan species caught, Table 1 also indicates the number of individuals captured, the descriptive statistics for size and weight, and the sex ratio (males:females) for each species.

Table 2 show catches of chondrichthyans and CPUE values per location. Mean CPUE per island surveyed varied from 0.00 off Lanzarote (no shark was caught) to 182.96 kg/1000 hooks off Fuerteventura, with low CPUE values for the remaining sampled islands.

DISCUSSION

With regard to the European Red List of Marine Fishes (Nieto et al. 2015), it is important to highlight that the leafscale gulper shark (*Centrophorus squamosus*), the most captured species in the survey, has been classified as an endangered species. Previously, this shark species was considered as highly vulnerable to depletion and consequently assessed as endangered in the northeast Atlantic (White 2003). Also, this species was included in the OSPAR List of threatened and/or declining species and habitats (Gibson et al. 2008). Moreover, the gulper shark (*Centrophorus granulosus*) has been recently catalogued as a critically endangered species (Nieto et al. 2015).

When compared with that of the by-catch identified from the black scabbardfish fishery off Madeira (Bordalo-Machado et al. 2009), chondrichthyan species composition was quite similar to the present results for the Canary Islands waters, except for the absence of the Portuguese dogfish *Centroscyrnus coelolepis* (Sommiosidae) and the birdbeak dogfish *Deania calcea* (Centrophoridae) off the Canaries. However, given that the present survey was carried out only in March, any type of seasonal distribution pattern in those species would have been missed.

In the eastern Atlantic, landings of the leafscale gulper shark, *C. squamosus*, the most captured species within the by-catch, over the past decade peaked in 2003 (3042 t) and declined to 243 t in 2009 (Ebert and Stehmann 2013). Based on FAO catch data, in Portugal average landings of this species were 893 t per year from 2000 to 2009. In contrast, short time series of CPUE available for the western coast of Portugal seem to indicate that these landings remain stable (Gibson et al. 2008).

According to the present results and concerns, further studies should be conducted in order to evaluate the real impact of this fishery on the northeastern Atlantic population(s) of the leafscale gulper shark, and should also address technological developments related to the fishing gear tending to minimize its catches.

In order to fully understand the trends of all species caught as by-catch in this fishery, it is important to monitor continuously to obtain representative time series.

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